VERIFICATION OF A TRANSLATION

I, Henry M. Feiereisen, having a place of business at 708 Third Avenue, Suite 1501, New York, N.Y. 10017, depose and state that:

1. I am familiar with the English and German languages.

2. I have read German language Application No. 103 26 167.2.

3. The hereto attached English language text is an accurate translation thereof.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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HENRY M. FEIEREISEN

FEDERAL REPUBLIC OF GERMANY

Priority Certificate Regarding the Filing of a Patent Application

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Applicant/Owner:	Siemens Aktiengesellschaft, 80333 Munich/DE
Title	Permanent Magnet Synchronous Motor
IPC:	H 02 K, K 21/02

The attached documents are a true and accurate reproduction of the original documents of this patent application.

(Seal)

Munich, 7 June 2004
German Patent and Trademark Office
The Commissioner
On behalf of

Description

Permanent magnet synchronous motor

The invention relates to a permanent magnet synchronous motor with tooth-wound coils in the stator and with a rotor.

In generic permanent magnet synchronous motors, oscillating torques occur. A skew of the rotor or stator by a slot pitch, as is described in the case of conventional motors in EP 0 545 060 B1, cannot be applied in the case of electric motors with a concentric winding, i.e. tooth-wound coils and a low slot number, since, as a result, the torque would be reduced to an excessive extent.

In the case of electric motors with a conventional winding, i.e. windings are produced using the draw-in technique, and in the case of a relatively high slot number, there is generally a skew of a slot pitch.

In the case of electric motors with tooth-wound coils, attempts are being made to reduce the oscillating torques by shaping the magnets in a particular way. One disadvantage with this is the fact that shaping the magnets in a particular way results in increased production costs.

Accordingly, the invention is based on the object of providing an electric synchronous motor whose rotor damps or suppresses relevant harmonics in a targeted and simple manner in order to reduce oscillating torques or the torque ripple.

The set object is achieved by a permanent magnet synchronous motor with tooth-wound coils in the stator and with a rotor which has structural means for damping the fifth harmonic and/or the seventh harmonic of the rotor field.

In this case, tooth-wound coils form at least part of a winding system of the permanent magnet synchronous motor, the tooth-wound coils in each case only comprising one mechanical pole, i.e. one tooth.

As a result of a skew of half a slot pitch, 0.5 x Tn, or as a result of a skew of 3/5 x Tn, complete elimination of the fifth harmonic of the rotor field is achieved. In this case, Tn denotes a slot pitch.

Given a skew of 3/7 x Tn, the seventh harmonic of the rotor field is eliminated.

The combination of this skew of 60% of a slot pitch Tn with a pole pitch factor of 85% results in complete damping or elimination of both the fifth and the seventh harmonics.

The combination of the skew of 3/7 x Tn with a pole pitch factor of approximately 80% also results in the complete damping or elimination of both the fifth and the seventh harmonics. Likewise, even a pole pitch factor of 80% +/-10% results in sufficient damping of the fifth harmonic.

A structural conversion of the skew does not need to be restricted to the rotor or stator; the effect of the skew of, for example, half a slot pitch can be divided proportionally between the stator and the rotor. In this case, for example, the stator takes on half of the half slot pitch and the rotor takes on the rest of the skew in order to achieve the desired skew.

The invention and further advantageous configurations of the invention will be explained in more detail with reference to a schematically illustrated exemplary embodiment. In the drawing:

figure 1 shows a basic illustration of a machine according to the invention,

figure 2 shows a magnet-wheel field of an electrical machine, and

figure 3 shows a perspective illustration of a rotor according to the invention.

Figure 1 shows a basic laminate section of a permanent magnet synchronous motor 1, with a stator 2 and a rotor 4. In this case, the pole pair number corresponds to one third of the number of slots 3 of the stator 2. The number of teeth 8 is a multiple of three, i.e. the number of winding phases of the stator 2, and is expediently greater than or equal to nine. The stator 2 is constructed from laminates, which have slots 3, into which the windings are inserted. In this case, the windings are in particular tooth-wound coils 6, i.e. a tooth-wound coil 6 comprises in each case only one tooth 8. The rotor 4 is constructed from permanent magnets 5, which can also be in the form of platelets, rings or shell-shaped magnets. In this case, these permanent magnets 5 are magnetized or arranged over the axial profile of the rotor 4 in such a way that the desired skew is set.

Such a rotor 4 produces a magnet-wheel field as shown in figure 2 in the air gap which has the following profile. Pole gaps are provided between the poles. Tp is the pole pitch and a is the pole pitch factor, which is generally in the range of from 0.8 to 0.95. The lower the pole pitch factor a, the lower the output torque of the synchronous motor. a = 1 is not possible for manufacturing-related reasons.

The magnet-wheel field illustrated in principle in figure 2 has harmonics as well as the fundamental. As regards the oscillating torques, primarily the harmonics of the orders five

and seven are relevant, with it being necessary to damp or completely eliminate these harmonics. The level of these harmonics depends essentially on the pole pitch factor a.

In order to damp the oscillating torques, the rotor 4 and/or the stator 2 is/are skewed. A measure for the skew is the skew angle 7 shown in figure 3. A skew factor can be defined from the skew angle 7, and this skew factor can be used to provide the damping of the individual harmonics of the air-gap field. The skew of the stator 2 may result from the skewed arrangement of the slots 3 of the stator 2 relative to the shaft 9.

According to the invention, the torque-forming fundamental is damped a little, and the relevant harmonics five and seven are eliminated. Both harmonics result in oscillating torques of the order 6p, i.e. 6p times the rotation frequency, where p is the pole pair number. An effective solution for avoiding the oscillating torques results from the skew of half a slot pitch, i.e. Tn/2. In this case, damping of the fifth harmonic to 19% and of the seventh harmonic to 13.6% results. At the same time, the most relevant cogging torque of twice the slot frequency is damped.

In the case of a pole pitch factor a of 0.8 or at least in the vicinity of 0.8, the fifth harmonic is 0. Now only the seventh harmonic still needs to be damped by the skew. For this purpose, the skew needs to be smaller than half the slot pitch, namely precisely 3/7 x Tn equal to 0.4285Tn.

Given a conventional pole pitch factor a of 0.85 or of around 0.85 up to 0.9, it is favorable to primarily damp the fifth harmonic, and correspondingly a skew of more than half a slot pitch is necessary, namely 3/5 x Tn. With this skew, the fifth harmonic is completely eliminated. The skew can be provided both in the rotor 4 and in the stator 2. In addition, it is possible to distribute the required skew over the entire

synchronous motor, i.e. both the rotor 4 and the stator 2 take on certain predeterminable proportions of the skew which is required overall, with the result that the skews are added in the air gap, and therefore the same effect is achieved as with the skew purely on the rotor 4 or the stator 2.

Patent claims

1. A permanent magnet synchronous motor (1) with tooth-wound coils (6) in the stator (2) and with a rotor (4) which has structural means for damping the fifth harmonic and/or the seventh harmonic of the rotor field.

2. The permanent magnet synchronous motor (1) as claimed in claim 1, characterized in that slots in the rotor (4) and/or the stator (2) have a skew which is between half a slot pitch and 60% of a slot pitch (Tn) with respect to the synchronous motor (1).

3. The permanent magnet synchronous motor (1) as claimed in claim 1 or 2, characterized in that a pole pitch factor (a) of 85% is provided.

4. The permanent magnet synchronous motor (1) as claimed in claim 1, characterized in that slots in the rotor (4) and/or the stator (2) have a skew which is between half a slot pitch and 0.4285 times a slot pitch (Tn) with respect to the synchronous motor (1).

5. The permanent magnet synchronous motor (1) as claimed in claim 1 or 4, characterized in that a pole pitch factor (a) of 80% is provided.

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Abstract

Permanent magnet synchronous motor

In order to reduce the torque ripple in permanent magnet synchronous motors (1) with tooth-wound coils (6), structural means are proposed for damping or eliminating the main causes of the torque ripple, the fifth and/or the seventh harmonics of the rotor field.

Figure 1

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FIG 1

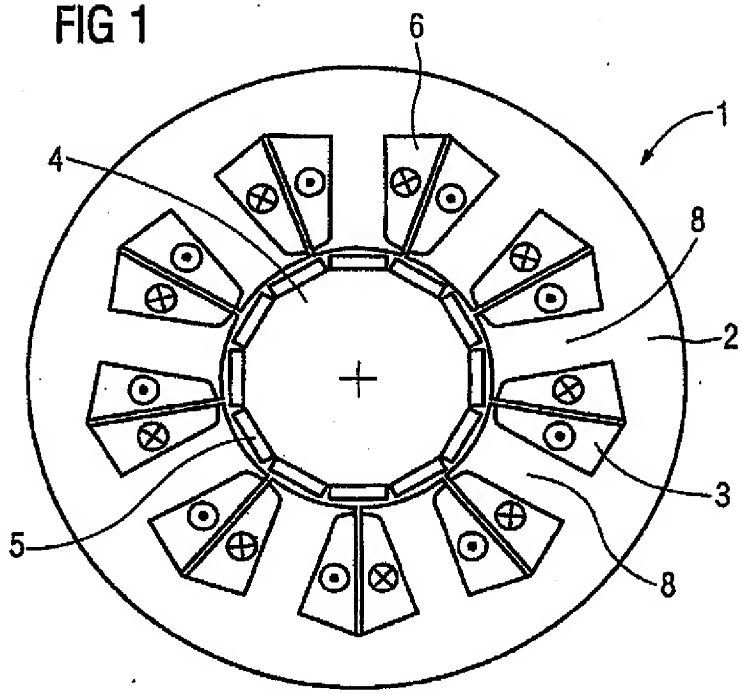

FIG 2

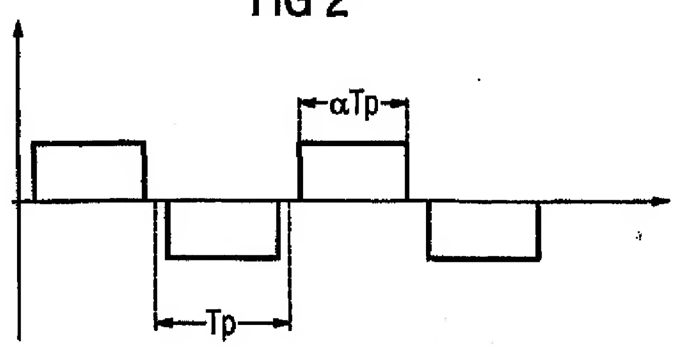

FIG 3